The Influence of Household Economics and Farming Aspects on Adoption of Traditional Agroforestry in Western Himalaya

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The Influence of Household Economics and Farming Aspects on Adoption of Traditional Agroforestry in Western Himalaya

The level of participation in any production or farming activity is considered to be linked to the diversity of economic and other farming conditions in a farming community at any given time. Many expert-designed agroforestry programs are adopted unevenly or not at all by the intended beneficiaries, especially in developing countries, because they are not built on existing experience with adoption of traditional agroforestry systems. The present study investigated the influence of economic and farming aspects on households' adoption of traditional agroforestry, to suggest strategies for further strengthening agroforestry adoption. The study was carried out in Mandi district of Himachal Pradesh, an Indian state located in the Western Himalaya. The main forms of traditional agroforestry in the study area are the agrosilvicultural, agrosilvihorticultural, silvopastoral, agrohortisilvicultural, hortiagricultural, and hortisilvicultural systems. The survey data were collected with a pre-structured questionnaire in personal interviews with household heads. The extent of agroforestry adoption was found to have increased significantly with increasing crop diversification, agricultural production, food sufficiency, agricultural income, off-farm income, total household income, number of livestock units, restrictions on on-farm grazing, and sale of horticultural as well as forestry tree produce from the farm. The study emphasizes the need for a holistic approach to agroforestry development by integrating agroforestry programs into other economic and agricultural development programs.

Keywords: *Agroforestry; household economics; adoption; traditional systems; Western Himalaya.*

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Introduction

Traditional agroforestry is the result of farmers' innovation and experimentation over centuries (Rafiq et al 2000). Adoption of innovations in agroforestry technology is a complicated process determined by both environmental and socioeconomic factors (Garforth et al 1999; Malla 2000; Neupane et al 2002). Most previous studies on agroforestry adoption have been concerned with *ex post* evaluations of projects in which social forestry or farm forestry programs funded by third parties or the government were implemented without taking account of both pre-project and traditional agroforestry practices. A comprehensive review of studies on agroforestry adoption by Sood (2003) shows that empirical investigations into the influence of economic and farming aspects on adoption of traditional agroforestry systems are non-existent. There is a tendency to emphasize biophysical aspects and tree-based needs in design of agroforestry technologies, without reference to economic and farming aspects of households (Scherr 1995b; Nair 1998). In most developing countries, the level of participation in any production activity can be linked to the socioeconomic status of households (Agarwal 1986). Keeping this in mind, it is essential to examine adoption of traditional agroforestry in relation to economic and farming conditions of households.

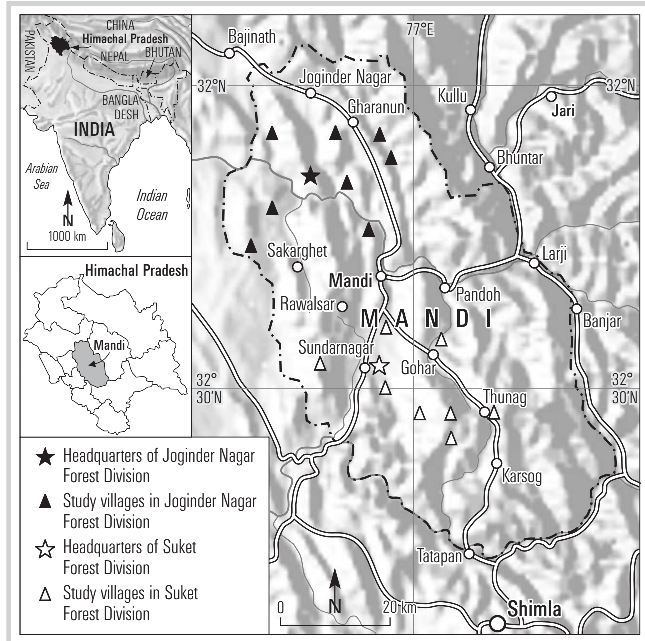
The Himalayas are ecologically fragile, and subsistence agriculture is the backbone of local livelihoods (Tiwari 2000). Tree cover is declining continuously in this region. Therefore, there has been an emphasis on increasing tree cover in this region (Myers 1999). The area available for cultivation and subsequently for increasing tree cover is limited in this region due to adverse climatic and topographic factors such as snowfall, glaciers, and very steep slopes. Accordingly, the need to encourage farmers to adopt agroforestry on farmland has been established (IIED 2000). The main aim of the present study was to investigate the influence of various economic and farming aspects on adoption of traditional agroforestry (extent of on-farm tree cultivation) in order to suggest strategies to encourage agroforestry adoption.

Study area

The study was carried out in Mandi district of Himachal Pradesh, an Indian state located in the Western Himalaya. This district is situated at 31°13′50″ – 32°04′30″ N and 76°37′20″ – 77°23′15″ E (Balokhra 1999). Ninety percent of the population in Himachal Pradesh inhabit villages whose economy is primarily dependent on agriculture, horticulture, silviculture, and animal husbandry (Atul et al 1994). There is limited scope for mechanized farming and industrialization due to very steep slopes and hilly topography (GOHP 2001). Government jobs are the second most important source of employment. Raising livestock meets the requirement for animal power in agriculture and provides both richly nutritious food (milk, meat, and eggs) and manure, and also represents a source of income (Balokhra 1999).

Forests play an important role in the economy of Himachal Pradesh, supporting rural livelihoods by providing fodder, fuelwood, timber, herbs, medicinal

FIGURE 1 Location of the study villages in Mandi district, Himachal Pradesh. (Map by Andreas Brodbeck)



plants, and small timber for agricultural implements, cattle sheds, huts, and fencing (Sharma et al 2000). People's average dependency on forests for fodder, fuelwood, and timber was reported to be 50%, 90%, and 85%, respectively (Singh 1995). The State forests are an important source of biodiversity, and IUCN–The World Conservation Union considers the region to be one of the world's priority conservation areas (IIED 2000).

Production systems

Cropping is carried out both in summer and winter but at higher altitudes the colder climate allows only summer crops. Maize, wheat, paddy, and millet usually dominate the cropping pattern. Horticultural trees include citrus, mango, and litchi at lower elevations, and apple, walnut, peach, almond, plum, and apricot at higher elevations. Crops are usually grown for home subsistence, but there have been major advances in cultivating commercial vegetables, mainly potatoes and peas (NRI 1991).

Agrosilvicultural (cultivation of trees yielding timber, fuelwood, and fodder along with agricultural crops), agrosilvihorticultural (cultivation of trees yielding timber, fuelwood, fodder, and fruit along with agricultural crops), silvopastoral (forest grazing), hortiagricultural (cultivation of agricultural crops along with fruit tree plantations), and hortisilvicultural (cultivation of trees yielding fruit, timber, fuelwood, and fodder) systems are the main forms of traditional agroforestry in the study area.

While there is natural regeneration of trees, farmers also plant their own (Verma and Mishra 2000). *Grewia optiva*, *Populus deltoides*, *Salix* spp., *Albizzia* spp., *Celtis australis*, bamboo, *Bauhinia variegata*, *Ulmus villosa*, *Toona ciliata*, *Prunus cerasoides*, *Quercus leucotrichophora*, *Cedrus deodara*, and *Pyrus pashia* are common multipurpose tree species occurring on the farms. Joint Forest Management (JFM) was started in 1993 in Himachal Pradesh.

Methodology

Data collection

As 25% of the population of this district are illiterate (Sood and Mitchell 2004), the data were collected with a pre-structured questionnaire in personal interviews with the heads of households. This was done from August 2001 to May 2002 in a cross-sectional survey. The data were supplemented by qualitative information gained through informal discussions with the farmers during the fieldwork. A pilot survey was carried out in the village of Chaugan in Mandi district, using a random sample of 25 households, after which the questionnaire was finalized (see Sood 2003 for questionnaire). The questionnaire contained information on economic and farming aspects of households and on the number of trees. In addition, it contained information on soil depth (depth classes ≤30 cm, 31–45 cm, and ≥46 cm), soil texture (clayey loam/fine texture, sandy loam/medium texture, and gravelly/coarse texture), perceived soil fertility (less fertile, moderately fertile, and highly fertile) of farms, and farm sizes (ha).

Multistage random sampling was used to select households with forestland villages, and households as the units of sampling at each successive stage. In this way 16 villages were selected (Figure 1). The sample consisted of one-third of the households from large (≥1 ha) and small (<1 ha) farmers for each selected village. The total sample size was 401 households.

Statistical analysis

Most previous studies on farmers' use of various farm technologies have concentrated on the *incidence* (yes/no) rather than on the *extent* of use (Feder et al 1985). As there was irregular spacing between trees on farms and different tree species had different crown forms, the area covered by trees (as an extent of agroforestry adoption) could not be reliably estimated in the current study. Instead, the number of trees per household was taken as a measure of the extent of agroforestry adoption. As the number of trees per farm did not follow a normal distribution, the difference between numbers of trees per household was tested across categories of independent variables. The nonparametric Mann-Whitney (Z denoting Mann-Whitney statistics) and Kruskal-Wallis (KW denoting Kruskal-Wallis statistics) tests were employed for independent variables with two and more categories, respectively. A critical significance level of 5% was adopted to test the sig-

TABLE 1 Influence of various economic and farming aspects on the extent of agroforestry adoption. AME = Adult Male Equivalent; ACU = Adult Cattle Unit; KW = Kruskal-Wallis; Z = Mann-Whitney; df = degree of freedom; p = probability value.

Variable	Category	Number of households	Mean rank[a)]	Median number of trees	Statistics and significance
Family labor available for agriculture (AME/ha)	0–4.0	166	283.5	131	KW = 178.893 df = 4 p < 0.0001
	4.01–8.0	92	195.1	36	
	8.01–12.0	50	129.29	13	
	12.01–17.0	39	121.1	10	
	≥ 17.01	54	83.44	7	
Crop diversification (number of crops per year)	2–4	194	147.4	14	KW = 94.380 df = 2 p < 0.0001
	5–6	153	153.0	58	
	≥ 7	54	301.7	153	
Cropping intensity (%)	≤ 150.0	89	189.9	30	KW = 3.687 df = 2 p < 0.158
	151.0–190.0	73	184.9	31	
	≥ 190.0	239	210.0	40	
Agricultural production (kg/year)	600 or lower	104	94.0	9	KW = 186.258 df = 3 p < 0.0001
	601–1300	100	176.1	21	
	1301–2000	71	217.9	38	
	≥ 2001	126	299.5	153	
Food sufficiency (%)	Nil (0)	14	67.0	0	KW = 158.428 df = 3 p < 0.0001
	Low (1.0–50.0)	116	111.5	7	
	Medium (50.1–100.0)	76	185.6	24	
	High (>100.1)	195	269.9	96	
Agricultural income (Rs/year)	No agricultural income	180	158.35	14	KW = 89.699 df = 3 p < 0.0001
	1–5000	96	179.06	25	
	5001–10,000	56	254.33	88	
	≥ 10,001	69	299.49	165	
Off-farm income (Rs/year)	0–15,000	62	108.54	6	KW = 119.109 df = 3 p < 0.0001
	15,001–30,000	112	144.14	12	
	30,001–60,000	99	235.93	58	
	≥ 60,001	128	268.52	86	
Total annual income (Rs/year)	18,000 or less	63	74.2	0	KW = 198.505 df = 3 p < 0.0001
	18,001–54,000	134	151.8	17	
	54,001–110,000	109	235.8	53	
	≥ 110,001	93	312.9	182	
Livestock (ACU)	0	46	159.61	12	KW = 17.312 df = 3 p < 0.001
	0.3–2.0	103	175.43	20	
	2.0–4.0	97	213.89	43	
	≥ 4.1	155	222.21	60	
Type of on-farm grazing	Free grazing	143	106.36	7	KW = 162.116 df = 2 p < 0.0001
	Restricted grazing	120	224.95	43	
	No grazing	138	278.24	100	
Type of grazing in State forests	Do not have livestock	46	159.61	12	KW = 66.293 df = 3 p < 0.0001
	Do not graze	148	257.81	75	
	Sometimes (1–2 times/week)	75	202.54	31	
	Regularly (> 2 times/week)	132	150.86	12	
Sale of horticultural produce	Do not sell	300	167.3	18	Z = 10.045 df = 1 p< 0.0001
	Sell	101	301.1	158	
Income from forestry trees (Rs/year)	No income	269	153.1	15	KW = 152.003 df = 2 p < 0.0001
	Up to 5000	84	272.2	86	
	≥ 5001	48	344.9	335	

[a)] Mean rank is for number of trees on farms.

nificance of association. The data were analyzed using SPSS software 11.0 for MS Windows.

The extent of tree growing included trees growing on farms as a result both of natural regeneration and planting by farmers. Food self-sufficiency was estimated using Sood's (2003) formula:

$$\text{Food Sufficiency (\%)} = \frac{\text{Total quantity of staple food crops (wheat and rice) produced per annum from householder's farm}}{\text{Total quantity of staple food crops (wheat and rice) consumed by household per annum}} \times 100$$

Adult cattle units (ACUs) were estimated using Upadhyaya's (1997) formula (Cow/bullock/horse/mule=1.00 ACU, Buffalo=1.30 ACUs, Young stock of cow/buffalo=0.75 ACU, Sheep/goat=0.15 ACU), adult male equivalents (AMEs) for household agricultural labor were estimated using Jacob and Alles's (1989) method (1 AME = 1 Adult Male = 1.4 Adult Females = 2.5 Children). Cropping intensity was estimated by dividing gross annual cropped area by net area sown and multiplying the figure by 100 (Chundamannil et al 1993). Cropping diversification was measured as the number of crops grown by a farmer per year.

Results

Table 1 shows the influence of various economic and farming aspects on the extent of agroforestry adoption (1 US$ ≈ 41 Indian Rupees [Rs] at 2002 rates). The results are described below for each economic and farming aspect of households.

Availability of family labor for agriculture

We hypothesized that less availability of family labor for agriculture would result in farmers' opting for less labor-intensive strategies such as tree growing, leading them to adopt agroforestry to a greater extent. Availability of family labor for agriculture refers to household labor being available for cultivation of agricultural crops. The extent of agroforestry adoption varied significantly with increasing number of family members available for agriculture per hectare of agricultural land (Table 1). There was a decline in the extent of agroforestry adoption with increased availability of family labor for agriculture.

Crop diversification (number of crops per year)

This hypothesis was based on the assumption that farmers with higher crop diversification would also adopt agroforestry as a means of diversification of farm activities. Crop diversification had a significant effect on the extent of agroforestry adoption by households (Table 1). There was an increase in the extent of agroforestry adoption with increasing crop diversification. Similar results were obtained by Shukla (1994).

Cropping intensity

Higher cropping intensities are presumed to leave less space for growing woody perennials. It may therefore be expected that higher cropping intensities will discourage agroforestry adoption. The extent of agroforestry adoption did not vary significantly with increasing cropping intensity in the present study (Table 1). The reason could be that protection from grazing by virtue of land being occupied by crops most of the time on farms with higher cropping intensity was offset by decreasing space being available for trees. Similar findings were reported by Mahapatra and Mitchell (2001) in Orissa, India.

Annual agricultural production

Our hypothesis was further based on the assumption that households with higher agricultural production would also tend to increase production of tree products, leading to greater adoption of agroforestry. The extent of agroforestry adoption varied with household agricultural production (Table 1). There was an increase in the extent of agroforestry adoption with increasing householders' agricultural production. Annual agricultural production showed a significant and positive correlation with food sufficiency (r_s=0.615; $p< 0.0001$) in the present study.

Food self-sufficiency

The extent of agroforestry adoption increased significantly with a rise in household food sufficiency (Table 1). Correlations were highly significant and positive between food sufficiency on the one hand, and landholding, soil fertility, and soil depth on the other (r_s=0.457, 0.641, 0.653, $p< 0.0001$), and negative between food sufficiency and soil texture (r_s= –0.480, $p< 0.0001$). This means that households with larger farms and with more fertile, deeper, and finer-textured soils were more food sufficient.

Annual agricultural income

As subsistence economy predominates in the study area, 44.9% of the farmers did not sell any agricultural produce. We hypothesized that higher income (agricultural, off-farm, and total incomes) would increase the risk-bearing capacity of households to adopt innovations, including those in agroforestry. The extent of agroforestry adoption increased with increasing agricultural income of households (Table 1).

Annual off-farm income

Off-farm income demonstrated a highly significant association with the extent of agroforestry adoption (Table 1).

Total household income

Income is a proxy for wealth status. The extent of agroforestry adoption showed a significant increase with increasing total household income (Table 1).

Livestock units

With increasing numbers of livestock units, farmers are more likely to adopt agroforestry, as there will be a higher demand for fodder. Possession of livestock by households had a significant influence on the extent of agroforestry adoption, as is evident from the Kruskal-Wallis test (Table 1).

On-farm grazing after crop harvest

Farm owners restrict grazing of other farmers' livestock on their farms after crop harvest to varying extents. This was categorized as free grazing, restricted grazing (grazing allowed on part of the farm), and no grazing. We hypothesized that grazing restrictions on farms would result in better protection of seedlings, with their establishment leading to a greater degree of agroforestry adoption. The extent of agroforestry adoption varied significantly with the type of on-farm grazing in the current study (Table 1). It showed an increasing trend with increasing restrictions on grazing (from free grazing to no grazing).

Level of livestock grazing in State forests

Livestock grazing in State forests reduces the gap between supply of and requirements for fodder. Thus households that graze their livestock in State forests would experience less fodder scarcity and therefore be less motivated to adopt agroforestry. The extent of tree growing also exhibited a decreasing trend with increased intensity of grazing in State forests (Table 1).

Sale of horticultural produce

We hypothesized that the income-generating potential of farm activities (including agroforestry) would affect household attitudes towards different activities in the production system. There was a significantly greater extent of agroforestry adoption in households that sold horticultural produce than in households that did not (Table 1).

Sale of produce from on-farm forestry tree species

There are *de jure* restrictions on the sale of forestry tree produce (particularly timber and other forms of wood) in the study area. These restrictions apply especially to more valuable tree species (based on price per unit volume of wood). *De facto* conditions are different. In some areas, farmers are allowed to sell tree produce (logs, wood) from species such as *Populus deltoides*, *Eucalyptus* spp., *Ulmus villosa*, *Bombax ceiba*, *Grewia optiva*, and *Celtis australis* because they do not grow profusely in State forests, which minimizes the chances of theft of these species from the State forests. For the present study, sale of tree produce (other than horticultural produce) from farms was considered. The extent of agroforestry adoption increased with the level of sale of tree produce from forestry tree species (Table 1).

Discussion

Agroforestry adoption increased significantly with increase in ACUs. This could be ascribed to greater demand for green fodder in households with more ACUs, particularly during the period when green grasses are not available in the study area. Thus the importance of tree fodder was well established in the present study. Increased restrictions on post-harvest grazing by other farmers' livestock had a positive influence on the extent of agroforestry adoption owing to improved protection of seedlings. Livestock grazing in State forests discouraged agroforestry adoption because livestock grazing reduces the fodder demand for stall feeding. As different (mixtures of) fodder resources are fed to different types of livestock during different seasons, farmers in the study area were not able to accurately indicate the quantities of fodder (crop residues, grass, and tree-leaf fodder) used. Therefore there is a need to measure the quantities of different fodder used by households and to determine their relationship with agroforestry adoption.

The increase in the extent of agroforestry adoption with increasing annual agricultural production could be due to soils of finer texture (better moisture retention) and with greater depth and fertility because tree establishment would be easier under such conditions. There were significant correlations between soil texture, depth, fertility on the one hand and annual agricultural production on the other ($r_s = -0.221$, 0.336, and 0.283, respectively; $p < 0.0001$), which confirms the initial assumption.

In the present study, food self-sufficiency of households was an important factor influencing the extent of agroforestry adoption. According to the theory of livelihood strategy, food security is an important household livelihood objective (Ellis 1998). The reason for the increase in the extent of agroforestry adoption with increasing food self-sufficiency could be that in the case of lower food sufficiency the emphasis of farmers is on growing staple crops to become food sufficient for livelihood security; tree growing is then of secondary importance.

The significant and positive correlations between household agricultural production and food sufficiency on the one hand, and soil fertility on the other, imply that agricultural production and food sufficiency can be improved by amelioration of soil fertility, which can subsequently increase the extent of agroforestry adoption.

Further significant and negative correlations between agricultural production and food sufficiency on the one hand and soil texture on the other imply that soils of finer texture lead to higher agricultural production and food sufficiency because of the high water holding capacity of such soils. Measures should thus be taken to increase the water holding capacity of soils to improve agricultural production and food sufficiency, which would ultimately increase agroforestry adoption.

The opportunity to sell on-farm horticultural and forestry tree produce encouraged agroforestry adoption. Thus horticultural trees should also be considered as an integral part of any agroforestry program. They are usually ignored by the Forest Department (the implementing agency for agroforestry programs), which is only concerned with forestry trees. Horticultural trees in pure plantations, rather than for agroforestry, are encouraged by the State Horticulture Department in the study area. The current study shows that selling horticultural and forestry tree produce is an opportunity to increase farmers' income, while these products also fulfill farmers' own domestic needs.

According to theories of innovation adoption and livelihood strategies, households with a higher socioeconomic status and with more resources can bear the risk of adopting innovations more easily and thus are innovators or early adopters (Scherr 1995a; Kragten et al 2001). Indeed, there was increased agroforestry adoption among households with higher off-farm, agricultural, and total incomes. Integration of agroforestry programs into ongoing rural development and agricultural programs is important to raise off-farm income, agricultural production, food sufficiency, agricultural income, and total income, which would consequently encourage agroforestry adoption. Farmers with greater agricultural diversification, spreading and reducing the risk of crop failure, also opted for agroforestry as a diversification strategy.

Contrary to expectations, constraints on family labor (AMU/ha) availability for agricultural operations resulted in increasing the extent of agroforestry adoption in the study area. This is in contrast to Costa Rica where no influence of shortage of family labor (for crop cultivation) on tree planting was noticed (Jones and Price 1985). Shortage of family labor for agricultural work could result in households opting for less labor-intensive land use. Tree growing is less labor-intensive than agriculture (Agarwal 1986; Arnold 1997; Malla 2000). Therefore, there was increased agroforestry adoption among households with less labor available for agriculture (greater number of trees on farms) than among households with more household labor available for farming. Retention of trees by natural regeneration further reduces the labor requirement for tree growing in the study area. Thus planning agencies should devise methods of on-farm tree regeneration (natural/planting) which would require less effort for establishment of tree seedlings.

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